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NRMP-IEA Input-Output Working Paper No. 7

CASE STUDY OF THE OTHER FOOD CROPS SECTOR

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Preface

NRMP-IEA Technological Scenarios

The Natural Resources Management Project (NRMP) assisted by USAID in association with the Institute for Economic Analysis (IEA) at New York University is carrying out a modelling exercise to project the economic, employment and environmental consequences of different development paths for the Indonesian economy. The purpose is to provide advice to the Indonesian National Planning Agency (BAPPENAS) to assist in the development of the next five-year plan (Repelita VI) and the next Long-Term Development Plan. The first stage of this work has already been completed with the support of the Environmental Programming Support Services Project of CIDA.

The analysis, of which the present paper is a component, will provide advice on the trade-offs and complementarities between the growth of income and employment on the one hand, and the levels of natural resource depletion and degradation of the natural environment on the other. For instance, it is important for policy makers to know how the development of the pulp and cement industries over the next 20 years is likely to affect air and water pollution and how costly or cost-saving it will be to adopt cleaner technologies than are being used now.

The analytical framework includes a dynamic input-output model covering all economic activities. The model is dynamic in two senses. First, it incorporates a representation of investment in which levels of sectoral investment depend on expected growth of output, the technology in use and levels of capacity utilisation. Secondly, the model is dynamic in that it explicitly incorporates projections of changes in technology for a range of sectors in the economy, including agricultural sectors, forestry, energy sectors and key manufacturing sectors.

Technological scenarios are developed for each of these sectors using detailed information about likely technological and institutional changes obtained from technical experts. They include expected changes in intermediate inputs, notably energy and raw materials, capital stocks and human resources of different skill types as well as expected changes in natural resource usage and environmental degradation associated with current and alternative future technologies.

This paper is one of a series of working papers prepared by NRMP and IEA researchers in collaboration with industry experts. The papers will form a vital part of the data base for the numerical computations. In addition, they will be valuable as stand-alone analyses of technological futures for a range of important industries in Indonesia.

It should be noted, however, that some of these working papers (especially those on manufacturing sectors) were prepared under severe time limits and should not be taken to represent the last word on technological change in the industries in question.

Introduction

This case study describes current and future technologies in the Indonesian other food crops production sector (Sector 2 in the NRMP-IEA 30-sector classification system). Three main types of agricultural products make up this sector: staple crops (maize, cassava, sweet potato, groundnuts and soybeans), vegetables and fruit. The sector covers only the technology of on-farm production of these crops, and does not include any further processing. The study makes estimations of natural resource demands and of some environmental impacts from other food crop production.

All non-plantation and non-rice food crops are aggregated in one sector in the 30-sector matrix, in the 75-sector matrix this expands to four sectors (maize, root crops and flour, vegetables and fruits, and other food crops). These limitations mean that a broad range of non-rice food crops, grown under widely differing conditions and with as at least equally varying physical and labour requirements, are highly aggregated. The currently available data on physical and labour inputs to non-rice food crops is extremely limited, both with regard to the number of crops for which data can be found and the apparently poor quality of available data.

Production methods are small-scale (farms averaging less than one hectare) and almost completely unmechanised, except for equipment used to apply pesticides, and rely on human and draft labour for all steps in production. Hand hoeing and cattle-drawn ploughs are used for land preparation, and seed or cuttings (cassava and sweet potato) planted by hand. Weeding, fertilising, other crop maintenance activities and harvesting are also performed using human labour.

Most of these crops are grown under rainfed conditions on sloping or undulating land; only a minor proportion are grown on unirrigated ricefields in rotation with rice. Most production within this sector is for own-consumption and only a relatively small proportion is grown commercially to meet urban demand. Increasing urban population and income-derived demand will increase both the scale and proportion of commercial production by 2020, especially for vegetables and fruits (World Bank 1992).

None of these crops, except cassava, are currently exported (quota-limited exports to Europe), and demand is primarily influenced by domestic factors such as population and income. Some studies foresee the possibility for exports of maize (Winrock International - WI 1992) in the future. There may also be opportunities for small-scale exports of specialty high-value, low-volume fruit (World Bank 1992).

By volume, staple crops accounted for some 78% of sectoral production and 87% of area in 1985, vegetables for 7% of production and 4% of area, and fruit for 15% of production and 9% of area. Average yields for each type of crop were: staples 4.07 tonnes/ha (t/ha), vegetables 7.23 t/ha and fruit 7.19 t/ha (BPS 1986a). These crops occupied a total of some 6.23 million hectares in 1985 - approximately 3.51 million ha on-Java and 2.15 million ha off-Java (Table 1). See Annex 2 for full details on area, yield and production for 1985 and 1990.

Table 1:
Area, Production and Yield of Other Food Crops 1985 and 1990.

	Area '000 ha	Output '000 t	Yield t/ha	% of Total area	% of Total output
1985					
Staples	5,394	21,946	4.07	86.5%	78.4%
Vegetables	260	1,882	7.23	4.2%	6.7%
Fruit	578	4,155	7.19	9.3%	14.9%
Total/Wt.Mean	6,232	27,983	4.49	100.0%	100.0%
1990 (est.)					
Staples	6,647	26,673	4.01	88.0%	78.2%
Vegetables	289	2,701	9.35	3.8%	7.9%
Fruit	600	4,332	7.22	7.9%	12.7%
Total/Wt.Mean	7,550	34,115	4.52	100.0%	100.00%

Source: Annex 2.

By 1990, total sectoral production had risen to 34.1 million tonnes, an increase of 4.04% p.a. and average yield for the sector by 0.13% p.a. to 4.52 t/ha. Production of staples had increased to about 26.7 million tonnes (an increase of 3.98% p.a.), but average staple crop yield had declined slightly to 4.01 t/ha (-0.28% p.a.).

Because 1989 is the latest year for which data is available for vegetables and fruit, this data has been pro-rated at the 1985-89 growth rates to give approximations for 1990; the 1989 data is presented in Annex 2. By 1990, based on these assumptions, vegetable production had increased to 2.70 million tonnes (an increase of 9.45% p.a.) and fruit production to 4.33 million tonnes (1.05% p.a.), with average yields for vegetables of 9.35 t/ha (6.64% p.a.) and fruit 4.33 t/ha (0.10% p.a.).

The share of staples in sectoral production remained stable at about 78% in 1990, while the share of vegetables had increased slightly to 8% and fruit declined slightly to 13% of the total. By 1990 total area harvested had increased by 3.91% p.a. to 7.55 million ha, some 4.18 million ha (3.56% p.a.) on-Java and 2.76 million ha (5.19% p.a.) off-Java.

A recent study by the World Bank (1992) suggests that demand for staple crops (except as stock feed) is likely grow very slowly to 2010, while there will be a significant increase in demand for vegetables and fruit as incomes rise. Several studies (WI 1992, SOW 1991 and World Bank 1992) all anticipate steady increases in land (and labour) productivity for these crops during this period.

As with rice production, Indonesia faces constraints on the area of land suitable for cultivation for this range of crops. According to estimates by RePPProT (1990), off-Java there are an additional one million ha potentially suitable for dryland arable crops and another 1.2 million ha for mixed arable and tree crops available for expansion. On-Java changes in land use, particularly in areas adjacent to major urban markets, are resulting from expansion of vegetable and fruit production (World Bank 1992). However, expansion of production on-Java will generally result in the replacement of irrigated rice cultivation by intensive cultivation of vegetables on a commercial basis. In addition, increases in demand for stock feed (maize and soybean) will result expansion of production both on- and off-Java, although soybeans are often planted in rotation with rice (ibid).

II Intermediate Inputs

The main intermediate inputs to production from the 1985 I-O table (BPS 1989) are listed in Table 2; Annex 1 provides a full listing. Fertiliser and pesticide account for nearly one third of intermediate inputs by value, and over one third of intermediate inputs to this sector come from within the sector. Paddy, retail and wholesale trade, livestock products and financial intermediaries are the only other sectors which individually account for more than 2% of intermediate inputs.

Table 2:
Sector 2 - Other Food Crops 1985: Proportions of Intermediate Inputs

SECTOR NAME	#	MRp	%
Fertilizer & pesticide	45	283774	30.9%
Paddy	1	128251	13.9%
Root crops & flour	4	121013	13.2%
Other farm food crops	6	95521	10.4%
Vegetables & fruits	5	65660	7.1%
Retail & wholesale trade	62	55278	6.0%
Livestock products	18	39428	4.3%
Financial intermediaries	70	22247	2.4%
Maize	3	20226	2.2%
Road transport	65	16016	1.7%
Total Int. Inputs	190	919490	

Source: NRMP-IEA 75 sector I-O model.

III Changes in Technological Coefficients to 2020

Two scenarios have been identified. Only one scenario (S1) has been fully developed for this sector. A Conservation Scenario (S2), which aims to maintain land productivity hence, indirectly, labour productivity, for upland staple crops is sketched in for the purposes of discussion. For the reasons given below it appears unlikely that major increases in productivity (on average) of land or labour are likely to be achieved in this sector. Rather, the main task to be confronted for the great majority of production in this sector will be maintaining the productivity of the land in the face large-scale soil erosion and soil nutrient losses.

Except for maize, all of the crops in this sector are grown by smallholders and are mainly grown for own-consumption, with a relatively small but increasing proportion entering commercial markets. There appears to be little stimulus or opportunity for intensification of production (e.g. major increases in fertiliser use) or mechanisation (e.g. land preparation) to achieve markedly higher levels of land and labour productivity. In addition, as many of these crops (particularly staples) are grown on sloping land with high rates of soil and nutrient loss through erosion, farmers will be faced with a struggle just to maintain current levels of yield. New areas that may be opened for cultivation have generally poorer soil and/or more steeply sloping land than existing areas (or they would have already been put under cultivation) and yields from these areas are unlikely to be as high as those achieved in existing areas.

Base Scenario (S1) - Continuation of Current Trends.

A Base Scenario for the years 1985-2020 was initially developed, based on a continuation of 1985-90 trends of changes in area and yields (see Annex 2). In this scenario crop production area (and productivity) expand to supply the growing demand for food, with most expansion occurring in production of vegetables and fruit. This first approximation was then compared with a food demand model for the years 1988-2010 prepared by the World Bank (1992), and rates of change in crop area and yield adjusted to achieve a better fit to the Bank's model.

The World Bank model is based on data from a number of Asian countries including Indonesia (recalibrated for Indonesia) and estimates changes in the composition of diet (mainly increasing proportion of vegetables, fruit and meat) resulting from changes (increases) in income and population. Of the four rates of growth in Gross Domestic Product (GDP) - 5%, 6%, 7% and 8% per annum - the 6% growth rate model was selected as being most consistent with growth rates assumed in the NRMP-IEA Input-Output model. The World Bank's model for expected demand was extended to the year 2020, using rates of change for the years 2010-2020 that mirror both the direction and degree of changes in their model. Details of the World Bank's model and its extension to the year 2020 can be found in Annex 3.

Overall, production in the sector is estimated to grow at 2.46% p.a. over the study period, with per capita consumption/annum of other crops increasing from 170 kg in 1985 to some 240 kg by 2020. It should be noted that production (and anticipated demand) for staples includes a growing proportion of maize and soybeans used as stock feed (about half by 2020) rather than being consumed directly. By the year 2020, the share of staples in the diet is expected to have declined to from 78% to 59% of the total, and the share of vegetables and fruit risen to 15% and 26% respectively.

The results of this exercise suggest that production of staple crops will increase at an average rate of about 1.62% p.a. over 1985-2020, with per capita consumption/annum increasing very slowly from about 133 kg in 1985 to 141 kg by 2020 (0.16% p.a.). On the other hand, production of vegetables is estimated to increase rapidly (4.80% p.a.) over 1985-2020, with per capita consumption/annum increasing from 11 kg in 1985 to 36 kg in 2020 (3.30% p.a.). Production of fruit is also expected to increase rapidly (3.71% p.a.), with per capita consumption per annum increasing from about 25 kg in 1985 to 54 kg in 2020.

With a continuation in current trends, and the estimated changes in the proportion of staples, vegetables and fruit demanded due to rising incomes, improvements in cultivation will result in a 40% increase in yields by 2020 (0.97% p.a.). Within the sector, increases in staple crop yields are estimated at 14% over 1985-2020 or 0.36% p.a.(with major differences between crops - e.g. cassava and sweet potato yields increase at less than 1% p.a.), vegetable yields are expected to increase by about 138% (2.50% p.a.) and fruit yields by about 60% (1.35% p.a.).

The increase in yields results from gradual improvements in the crop varieties available to farmers, particularly maize, groundnuts and soybeans, and in the use of inputs, particularly fertiliser (Table 3). The increase in yields is wholly responsible for changes in land and labour productivity.

Fertilizer and pesticide: Fertiliser use per hectare for maize, groundnut and soybean use will rise more slowly than yield increases (due to increasing efficiency of use), while its use on cassava and sweet potato will remain negligible. Fertiliser use per hectare on vegetables will rise more slowly than yields (again, due to increasing efficiency of use), but the proportion of area of vegetables on which fertiliser is used will increase, due to more intensive commercial production; fertiliser use for fruit will remain negligible. Inputs of pesticide per hectare (which are currently very low) are expected to decline per unit of production for staples in line with yield increases, but are likely to increase for vegetables and fruit, unless integrated pest management (IPM) is adopted more widely.

Table 3:
Base Scenario - Changes in Technological Coefficients to 2020 (Inputs per tonne of Other Food Crops produced).

Input	Sector	1985	Change
Fertilizer & pesticide	45		0%
Urea (kg)		15.122	
Other fertilisers (kg)		17.769	
Pesticides (kg)		0.095	
Seed	2		-29%
Seed (kg)		5.839	
Financial intermediaries	70		+10%
Retail & Wholesale trade	62		0%
Labour			-29%
Human labour (person-years)		0.0804	
(person-days)		24.112	
Draft Labour (cattle-days)		3.638	
Tractors (machine-days)		0.0	
Water			n/a
Irrigation (cubic metre)		n/a	
Land Requirements			-29%
dryland (ha)		0.2227	
Environmental Impacts			
soil erosion (t/t output)		6.088	+10%
1985 Unit price (Rp/t)		75,833	

Notes: Data on labour and physical inputs in this table is drawn from a technical working paper on the sector, prepared in December 1992. Details on estimation procedures and data can be found in Annex 2.

Because of the domination of the sector by staple crops, most of which are grown on sloping land where loss of soil fertility due to erosion is high, and for which the land area required per unit of production will only marginally decrease (-12%) by 2020, increased fertiliser use per unit area will be required to maintain (or increase) staple crop yields. Taking into account increased fertiliser use on staples and greater use for intensive commercial vegetable production, it is estimated that average use per unit of production will not decline, despite the decrease in land area required per unit of production (-29%) to 2020.

Seed: Inputs to production listed in Table 2 coming from within the sector (paddy, root crops, other farm food crops, vegetables and fruit and maize) are assumed to be used for seed for the following crop season.

Use of seed per unit of production is estimated to decline at the same rate as land requirements, i.e. -29% over 1985-2020.

Financial intermediaries: The increased share of commercial production in the sector, particularly vegetables and fruit, will increase the reliance of commercially-orientated farmers on credit facilities. But, because of the dominance of production for own consumption, the overall impact will be minor. A rough estimate for this input is an increase of 10% per unit of production by 2020.

Retail and wholesale trade: Given the increasing complexity of agricultural input supply and food distribution - due in part to greater urbanisation - it is anticipated that it will require more resources to supply inputs to (and distribute and market) production than in 1985. This may be balanced by improvements in transport (fuel) efficiency. However, the dominance of production for own-consumption will remain, thus there will be only minor change, overall, in the pattern of supply of inputs. On balance, no change is anticipated.

Labour Requirements

Increasing yields will, overall, reduce weighted per unit of production labour requirements by the same amount (-29%) over 1985-2020. For staple crops the decline in labour requirements per unit of production is likely to be minor (in line with the minor increase in yields). However, for vegetables and fruit, increases in yield will result in substantially less labour being required per unit of production (-60% and -38% respectively).

Given the increased commercialisation of vegetable and fruit production, it is anticipated that the labour force in this sector will have become considerably more skilled by 2020.

Natural Resource Inputs

Unirrigated, undulating or sloping land is the main natural resource input to production in this sector, except for a minor proportion of these crops grown on unirrigated ricefields in rotation with rice.

Land requirements: Land requirements are dependant on yields, which are expected to increase overall by 40% by 2020. As a result the average land requirement per unit of production will decline by about 29% by 2020, with more substantial declines for vegetables (-60%) and fruit (-33%) than for staples (-12%).

Environmental Impacts

The main environmental impact of crop production in this sector is soil erosion, resulting in loss of soil mass and reductions in soil fertility; downstream effects include siltation of waterways, dams and harbours, including increased probability of flooding during the wet season.

Soil Erosion: Dryland staple crop production is undoubtedly responsible for both the high rate and great majority of soil and nutrient loss within this sector, because of its scale (87% of total area) and the fact that cultivation commonly takes place on land with slopes over 7%. Vegetables are usually cultivated on flat to slightly sloping land, fruit production is extensive with little disturbance of the soil after crop establishment.

Because of the extension of cultivation onto more marginal and sloping land, and more intensive cultivation of some staples and vegetables, it is expected that per unit production soil erosion is likely to increase, if there is no large-scale change to more conservation-orientated cultivation techniques.

Estimation of soil erosion per unit of production in 1985 was based on an assumption of a loss of between 44 tonnes (mildly sloping land) and 200 tonnes (steeply sloping land) per ha per annum (Euroconsult 1989), and an average crop duration of 100 days. Using an average figure of 100 t/ha/annum results in per crop losses of 27 tonnes per crop/ha, with average yields in 1985 of 4.5 t/ha, soil losses were 6.088 tonnes per tonne of production.

Based on this general (but conservative) evaluation, and despite an increase in yields, an initial estimate of an increase of 10% per unit of production to 6.697 tonnes per tonne of production is proposed. However, this estimate may be too low, given the extension of cultivation into more marginal and sloping lands.

Conservation Scenario (S2)

The widespread adoption and practice of soil conserving crop cultivation methods would probably be the most important and positive change in production technology for this sector, particularly for staple crop production on sloping lands. Without major efforts to reduce soil and soil nutrient losses it will be difficult to sustain both yields and the extent of cultivation, given current rates of erosion. For example, work by Repetto et al (1989) suggest that soil fertility losses may reach 7% p.a. for crops cultivated on sloping land if active soil conservation practices are not followed, i.e. soil fertility is halved every 10 years - resulting in a major decline in yields.

Reducing soil nutrient losses to less than half their current levels, for example, would have the same effect as supplying an equivalent level of manufactured nutrients required to maintain yields at their current levels. Moreover, conserving both soil nutrients and structure, particularly on steeply sloping land where soil erosion is most rapid, is equivalent to extending the productive life of agricultural land now under threat and maintaining (or increasing) labour productivity. Changes in cropping practices would need to be focused on areas where soil erosion is doing most damage, as not all land on which non-rice crops are grown is subject to high rates of soil erosion.

The short- to medium-term costs of implementing farm-level soil conserving cultivation practices needs to be set against the long-term decline in land and labour productivity due to soil and nutrient losses. In addition, there are real, off-site erosion costs (e.g. siltation of rivers, dams and harbours) that would be reduced by an effective soil conserving approach.

Soil conservation on hillsides relies on developing terraces on which crops are cultivated (to reduce runoff and increase water infiltration), ploughing and planting along the contour, and ensuring there is continuous vegetative cover. The traditional approach requires major earthworks to construct terraces, this approach is labour-intensive and often results in increased rates of erosion during and after terracing. An alternative approach is to plant deep-rooting grasses, shrubs and/or trees at appropriate intervals along the contour and use the build-up of soil behind them to gradually create a terrace; the species used can be selected with a view to providing additional income, stock fodder or fuel. This method is slower, but requires less labour and does not risk major soil losses during construction.

In addition to terracing, farmers will need greatly improved information on and assistance in selecting crop species and cultivation techniques that minimise soil losses. This requires a radically improved dryland research and extension system (World Bank 1992). In addition, given the small farm size (especially on Java) active cooperation between farmers working on a hillside or within a minor catchment is essential; land consolidation may be necessary. A combination of appropriate terracing, cultivation practices and crop selection can reduce soil losses to about one tonne per hectare per annum, increase water availability and improve yields (Euroconsult 1989).

It is extremely difficult to establish the amounts of labour and other inputs required and the changes in yields that might result from an active conservation scenario, given the wide range of conditions under which dryland crops are grown in Indonesia. Assuming that approximately 15% of the land area will need to be devoted to terrace-vegetation, this will result in a similar short-term loss of production. Hence, in the short- to medium-term (1-5 years), land required per tonne of production will increase by about 15%, and in the medium- to long-term term (5-10 years) increasing yields due to improved soil fertility and water retention should result in a decline in land requirements. Medium-term improvements in soil fertility should also result in a reduction in the use of manufactured fertiliser required per unit of production.

Establishing terrace vegetation will require a major once-off investment of labour, with minor amounts required each season or year for maintenance and/or harvesting. Very roughly, it is estimated that labour requirements per tonne of production will increase by about 10% in the short-term, and decline by a similar (or possibly greater) amount in the medium-and long-term

due to increased yields. However, the level of skill required to successfully practise soil-conserving farming will increase requirements for skilled labour.

Summary of Technological Coefficients for 1985 and 2020

The Technological Coefficients for this sector for 1985 and 2020 (S1 and S2 scenarios), based on the foregoing assumptions and estimations, are summarised in Table 4 below.

Table 4:
Technological Coefficients for Sector 2 - 1985 and 2020.
Other food crops (column).

				S1	S2
A MATRIX					
2	Other food crops			-29	-24
14	Fertiliser & pesticides			0	-15
L MATRIX					
Total employment per unit output			-28	-14	
B MATRIX					
Total new capital requirements				0	0
UNIT PRICE 1985		Rp/tonne			266,915
N MATRIX					
Land area		ha/t	.2227	-29	-24
Soil erosion		tonnes/t	6.088	+10	-50

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Annex 1:
Sector 1 - Other Food Crops 1985: Values of Intermediate Inputs (from 75 sector NRMP-IEA I-O model).

SECTOR NAME	#	MRp	%
Fertilizer & pesticide	45	283774	30.9%
Paddy	1	128251	13.9%
Root crops & flour	4	121013	13.2%
Other farm food crops	6	95521	10.4%
Vegetables & fruits	5	65660	7.1%
Retail & wholesale trade	62	55278	6.0%
Livestock products	18	39428	4.3%
Financial intermediaries	70	22247	2.4%
Maize	3	20226	2.2%
Road transport	65	16016	1.7%
Fabricated metal products	54	12194	1.3%
Construction	61	9365	1.0%
Textile, leather & apparel	37	7239	0.8%
Other crops	17	7034	0.8%
Other services	74	6389	0.7%
Poultry & products	20	5324	0.6%
Wood and cork products	42	4935	0.5%
Petroleum refinery	47	4917	0.5%
Water transport	66	3437	0.4%
Services allied to transport	68	2359	0.3%
Woven goods other than plastic	43	1826	0.2%
Rubber & plastic wares	49	1296	0.1%
Wood	21	1115	0.1%
Communication	69	744	0.1%
Coconut	9	736	0.1%
Machines & electrical machine	55	629	0.1%
Paper, cardboard & products	44	584	0.1%
Social & Community services	73	508	0.1%
Chemicals	45	230	0.0%
Other products n.e.c.	57	290	0.0%
Restaurant & hotels	63	222	0.0%
Railway transport	64	135	0.0%
Air transport	67	274	0.0%
Real estate & business services	71	294	0.0%
Total Int. Inputs	190	919490	100.0%

Source: BPS 1989.

Annex 2

Estimation Procedures and Results for Other Food Crops Technological Coefficients

Introduction

This annex presents the results of an investigation into production processes for non-rice food crops. It focuses on production in 1985 and 1989, with the aim of estimating technological production coefficients for 1985 and developing the Base Scenario for 2020.

All non-plantation food crops are aggregated in one sector in the 30 sector matrix, and in the 75 sector matrix this expands to four sectors (maize, root crops and flour, vegetables and fruits, and other food crops). These limitations mean that a broad range of non-rice food crops, grown under widely differing conditions and with as at least equally varying physical and labour requirements, are lumped together in one sector. Likewise, on the output side in the 30 sector matrix the nutritional and food energy content of this range of food crops varies widely from crop to crop, and these are also lumped together; the situation with the 75 sector matrix is similar.

Notes on Data Sources

The currently available data on physical and labour inputs to non-rice food crops is extremely limited, with regard to the number of crops for which data can be found and in terms of the poor quality of available data. This is evidenced, at the most superficial level, by inconsistencies between various government publications used for this study.

Labour and Physical Inputs

Data on human labour and physical inputs for 1985 for three major non-rice crops was obtained: cabbage, soybean and potato. For one of these crops (soybean) it is clear that the data on production inputs is from local data collected, *pro forma*, for the source cited below; only for potato is it clear that primary data was collected from farmers (Table A1). Additional data on physical inputs to production of maize, cassava, sweet potato, groundnuts and soybeans is available from *Struktur Ongkos Uasha Petani* for 1985, but this source lacks information on the physical quantity of human and draft labour inputs to production.

These data should be assessed in the light of the following table (Table A2), based on data extracted from *Struktur Ongkos Usaha Tani* for 1985. Direct comparison between the two data sets is only possible for soybean, where it appears yield per hectare may have increased substantially between 1985 and 1990 (963 to 1350 kg/ha). The level of physical inputs used to achieve this yield increased substantially, particularly use of TSP fertiliser. However, there is no reason to believe that human labour inputs have increased at the same rate, as applying

additional physical inputs requires little or no additional time, i.e. it does not take appreciably longer to apply 37 kg/ha of urea than to apply 45 kg/ha. It is assumed that the labour required for land preparation and crop maintenance per hectare have remained stable, while the labour required for harvesting increased roughly in proportion to the increase in yield.

Table A1:
Physical and Human Labour Inputs to Soybean, Cabbage and Potato Production.

Input	Soybean kg/t	Cabbage kg/t	Potato kg/t
Seed	29.815	7.67	1,189.3
Urea	37.269	21.47	-
TSP	55.903	25.46	-
KCL	55.903	16.15	-
ZA	-	16.44	-
Fertiliser	-	-	1,325.7
Pesticide	2.348	-	84.0
Compost	-	1172.06	1,971.5
Human Labour Inputs	days/t	days/t	days/t
Pre-Harvest	63.523	11.04	249.3
Harvest	10.454	6.05	148.7
Total	73.977	17.09	397.5
Production (kg)	1,350	14,730	16,500

Source: Various CASER 1991 and 1992 publications.

It is worth noting that two of the crops for which only cost data is available for labour inputs - groundnut and soybean - have much higher costs per tonne of production (Rp 48-60,000/Tm) than does maize (Rp 18,000/Tm) or the two tuber crops, cassava and sweet potato (Rp 3,500-5,600/Tm). This difference is in large part the result of the almost order-of-magnitude difference in the volume of production per hectare between tuber crops and the three other crops. Labour costs per hectare show much less variation.

Table A2:
Physical Inputs and Labour Costs for Maize, Cassava, Sweet Potato, Groundnut and Soybean - Indonesia 1985.

Input kg/t	Maize	Cassava	Sweet Potato	Ground Nut	Soybean
Seed					
Purchased	4.800	0.000	0.000	37.981	26.251
Own production	9.393	0.000	0.000	22.116	12.918
Total	**14.193**			**60.097**	**39.169**
Pesticide					
Insecticide	0.146	0.004	0.009	0.415	1.994
Other	0.011	0.001	0.008	0.174	0.156
Total	**0.157**	**0.005**	**0.017**	**0.589**	**2.150**
Fertiliser					
Urea	**53.834**	**1.396**	**2.374**	**40.589**	**44.663**
TSP/DAP	13.654	1.341	0.704	39.498	33.531
Others	1.692	0.110	0.103	1.507	2.461
Manure	0.000	0.000	0.000	0.000	0.000
Ofert - total	**15.346**	**1.450**	**0.807**	**41.005**	**35.992**
Labour (Rp '000/ha)	32.113	38.291	49.106	62.809	46.631
Labour (Rp '000/t)	18.051	3.556	5.613	60.685	48.423
Production (t/ha)	**1.779**	**10.769**	**8.749**	**1.035**	**963**

Source: Based on Struktur Ongkos Usaha Tani 1985, BPS 1988a.

Recent data on human labour inputs to cereal crop cultivation are difficult to obtain. Somewhat dated data on human and draft labour inputs and physical inputs are available from the Bali Irrigation Service (PU 1978) for each of the cereal crops of interest, these are presented below (Table A3).

Table A3:
Human, Draft Labour and Physical Inputs to Staple Crop Production.

days/kg kg/ha	Rice	Maize	Cassava	Sweet Potato	Ground Nut	Soybean
Human Labour	328.4	132.5	118.8	62.8	155.1	65.7
Draft Labour	16.9	26.1	17.6	15.8	21.1	2.5
Seed	35	25	-	-	150	40
Urea	150	-	-	-	-	-
TSP	35	-	-	-	-	-
Pesticide	2	3	-	-	2	2
Production	2,228	1,300	8,600	8,500	970	773

Notes: Labour inputs are in days/ha, and physical inputs in kg/ha.
Source: PU 1978.

For the six cereal crops, the human and draft labour inputs, divided by contemporary levels of production per hectare provide another estimate of labour inputs per tonne of output. These calculations are presented below (Table A4).

Table A4:
Human and Draft Labour Inputs to Staple Crop Production.

	Rice	Maize	Cassava	Sweet Potato	Ground Nut	Soybean
days/ha						
Human Labour	328.4	132.5	118.8	62.8	155.1	65.7
Draft Labour	16.9	26.1	17.6	15.8	21.1	2.5
Production (kg/ha)	4,804	1,779	10,769	8,749	1,035	963
days/t						
Human Labour	66.914	74.48	11.032	7.178	149.855	68.224
Draft Labour	3.486	14.671	1.634	1.806	20.386	2.596

Sources: Based on Tables 2 and 6.

A comparison with data on labour inputs from CASER (1991) for soybean shows reasonably good agreement: 68.224 vs 73.977 days of labour per tonne. Unfortunately, except for rice production, no other data on human (or draft) labour inputs to production are available.

The CASER (1991) data lack information on the amount of draft labour used in land preparation. To overcome this lack, the human labour inputs per tonne of cabbage production (specifically for land preparation from the CASER data) have been calculated, and an assumption made that the duration of draft labour is equivalent to half this.

As a pair of cattle is used in ploughing, the duration of total draft labour inputs is, thus, numerically identical to the duration of human labour inputs to land preparation. Land preparation is generally accomplished using a mixture of ploughing and hoeing, and the balance between these methods varies between crop species and soil types. As a result both of the lack of comparative data and of inter-species variations, there is no means of knowing whether this estimate of draft labour inputs is an over- or under-estimation. In addition, only for cabbage is it possible to make an estimate of draft labour inputs, because of the way in which the data is presented in the sources.

In general, it is highly probable that the amount of human and draft labour and other purchased physical inputs to vegetable and fruit production is greatly influenced by whether or not the crop is for own-consumption or sale. All of the crops investigated by CASER (1991) were produced for sale; we have no information on the proportion of national production of any specific crop (even rice) that is for own-consumption versus sale. It is, therefore,

probable that the level of inputs used for growing the crops investigated by CASER is higher than average - but we have no means of estimating the difference from the available data.

In an attempt to account for the relative importance of different crops in the food economy, the aggregate level of inputs into the non-rice food crops sector is a composite of the weighted average of inputs to each of the major staple crops (maize, cassava, sweet potato, groundnut and soybean), weighted in proportion to 1985 annual production of each of these crops. Inputs to vegetable crops is based on the data available for cabbage, with the caveat that this data undoubtedly over-estimates inputs for some other crops. The annual quantity of production of non-rice food crops is listed in Table A5.

For perennial tree crops (i.e. fruit) there are additional problems in making estimates of the inputs required per unit of output, to do with consistently taking account of the inputs necessary for establishment of trees and plantations. Here the assumption is made that inputs necessary for tree crops are half the level of inputs required for vegetables, and that this level of inputs accounts for both the establishment costs (spread over the productive life of the tree) and annual maintenance and harvesting labour inputs.

It should be noted that much if not most commercial production - output that is sold from indigenous tree crops, e.g. banana, durien - is undertaken by smallholders who only own one or two trees of each species. Only for some new tree crops, such as oranges and apples are medium- or large-scale specialised, monocultural plantations established. One of the consequences of this highly fragmented and dispersed production 'system' is that national production statistics are, on the whole, not much better than the aggregated result of guesses at the number of trees and their productivity made by local agricultural officials. We thus have, especially in the figures used here for the physical and labour inputs to vegetable and fruit production, guesses piled on guesses!

Table A5:
Non-Rice Food Crops - National Production 1985.

	tonnes	% of Group	% of Total
Staples			
Maize	4329503	19.73%	13.90%
Cassava	14057027	64.05%	45.14%
Sweet Potato	2161493	9.85%	6.94%
Groundnut	527852	2.41%	1.70%
Soybean	869718	3.96%	2.79%
Sub-Total Staples	**21945593**		**70.47%**
Vegetables			
Red onion	361058	7.16%	1.16%
White onion	61143	1.21%	0.20%
Spring onion	144867	2.87%	0.47%
Potato	372825	7.40%	1.20%
Cabbage	665445	13.20%	2.14%
Carrot	71351	1.42%	0.23%
Lobak	22332	0.44%	0.07%
Petsai/Sawi	189430	3.76%	0.61%
Beans (mixed)	54953	1.09%	0.18%
Chilli	341564	6.78%	1.10%
Tomato	160018	3.17%	0.51%
Cucumber	239948	4.76%	0.77%
Labu	89264	1.77%	0.29%
Aubergine	164699	3.27%	0.53%
Green Beans	89740	1.78%	0.29%
Kangkung	100244	1.99%	0.32%
Bayam	67474	1.34%	0.22%
Beans - other	272431	5.40%	0.87%
Other #1	1525387	30.26%	4.90%
Other #2	46768	0.93%	0.15%
Sub-Total Vegetables	**5040941**		**16.19%**
Fruit			
Avocado	62802	1.51%	0.20%
Mango	416444	10.02%	1.34%
Rambutan	93282	2.25%	0.30%
Duku/Langsat	53032	1.28%	0.17%
Durian	150575	3.62%	0.48%
Sawo	51295	1.23%	0.16%
Papaya	255423	6.15%	0.82%
Banana	1908627	45.94%	6.13%
Pineapple	308762	7.43%	0.99%
Salak	94889	2.28%	0.30%
Oranges	485236	11.68%	1.56%
Jambu	199027	4.79%	0.64%
Others	75588	1.82%	0.24%
Sub-Total Fruit	**4154982**		**13.34**
Grand Total	**31141516**		

Sources: BPS 1986a and BPS 1986b.

Table A6A:
Weighted Mean Estimates of Physical and Labour Inputs to Non-Rice Food Crop Production 1985 (including Cassava).

	Output Mt	% of Total	Seed kg/t	Urea kg/t	Ofert kg/t	Pest kg/t	Human days/t	Draft days/t
Staples	21.946	70.47%	5.789	14.495	6.386	0.135	28.770	4.172
Vegetables	5.041	16.19%	7.670	21.470	58.050	0.000	17.090	2.110
Fruit	4.155	13.34%	3.835	10.735	29.025	0.000	8.545	1.055
Wt.Mean	31.142	100.00%	5.839	15.122	17.769	0.095	24.181	3.803

Notes: % of Total = percentage of total quantity of non-rice food crops in tonnes, Ofert = other fertilisers, excluding compost, Human = human labour inputs, Draft = draft labour inputs, Wt. Mean = weighted mean. Mt = million metric tonnes.
Sources: Based on Tables A1, A2, A4 and A5.

In the above table of technical coefficients (Table A6A) the results are 'biased' because of the great volume of tuber crops - cassava alone accounts for some 45% of the total quantity produced, sweet potato adds another 7% - completely overwhelming the contribution by other crop species. This is particularly important in the estimation of the amounts of seed needed, as for neither of these two crops are estimates of seed use rates available. (This appears to be partly the result of classification, as both species are propagated vegetatively from cuttings, and partly because cuttings from neither crop enter the market.)

For cassava and sweet potato, but cassava in particular, farmers use minimal amounts of labour, either human or draft, in land preparation and crop maintenance; and the use of fertiliser or pesticide on these two crops is uncommon. In the case of maize, the levels of human and draft labour used seem to be far too high - higher than used for rice cultivation. This then has the effect (because of the prominace of maize after the 'removal' of cassava) of causing an overestimation of the per unit output labour inputs for the whole sector. It this case, the old data (specific to Bali) on levels of labour inputs may be the real source of the problem. This is a clear example of the need for more recent and representative data on cultivation inputs used for crops included in this sector.

The dominance of a sectoral coefficient by one or two products (species) raises the issue of how to avoid distorting results that are weighted by quantity. One solution, particularly where one or two species have no reported input in the particular category (e.g. seed, pesticide, labour, etc.) is to remove them from the weighting scheme for that category of input. A second solution is to derive the weights on another basis, for instance on the unit value of output. In this approach the low value/high weight nature of tuber crops would be balanced by the high value/low weight characteristics of other more valuable crop species, e.g. fruits and vegetables.

The numerical effect of this 'unwarranted' dominance by, in this case one crop (cassava), is to reduce the weighted average level of inputs for the sector as a whole to unreasonably low levels (Table A6A). To illustrate the impact of this, cassava was removed from the sectoral estimates, resulting in the values in the following table (Table 6B). This is considered a less than satisfactory approach to a solution. It is suggested that if i the future unit values are available for the crops included in this sector, they be used to derive weighted values for individual (and sub-sector) input coefficients, and the results of this estimation compared with those in these two tables, before making a decision about the final method to employ.

Table A6B:
Weighted Mean Estimates of Physical and Labour Inputs to Non-Rice Food Crop Production 1985 (excluding Cassava).

	Output Mt	% of Total	Seed kg/t	Urea kg/t	Ofert kg/t	Pest kg/t	Human days/t	Draft days/t
Staples	7.889	46.17%	16.129	37.836	15.355	0.367	60.375	10.197
Vegetables	5.041	29.51%	7.670	21.47	58.050	0.000	17.090	2.110
Fruit	4.155	24.32%	3.835	10.735	29.025	0.000	8.545	1.055
Wt.Mean	17.085	100.00%	10.643	26.416	31.277	0.170	34.998	5.588

Sources: Based on Tables 1, 2, 4 and 5.

The same problem of dominance of the data by one or two crop species exists with respect to output per unit area. This is illustrated in the data presented in Tables 7A and 7B. In this case, per unit area yields for the sector as a whole are changed significantly (7.845 vs 5.347 t/ha), depending on whether or not cassava is included in the estimation.

Table A7A:
Weighted Mean Estimates of Land Area Required for Non-Rice Food Crop Production 1985 (including cassava).

	Area ha	Output tonnes	Yield t/ha	% of Total t	% of Total ha
Staples	5394154	21945593	8.215	70.47%	69.28%
Vegetables	1814097	5040941	5.478	16.19%	23.30%
Fruit	577762	4154982	8.755	13.34%	7.42%
Total/Wt.Mean	7786013	31141516	7.845	100.00%	100.00%

Sources: Based on Tables 5, 6, 8, 9 and 10.

Table A7B:
Weighted Mean Estimates of Land Area Required for Non-Rice Food Crop Production 1985 (excluding cassava).

	Area ha	Output tonnes	Yield t/ha	% of Total t	% of Total ha
Staples	4102309	7888566	3.463	63.17%	46.17%
Vegetables	1814097	5040941	5.478	27.93%	29.51%
Fruit	577762	4154982	8.755	8.90%	24.32%
Total/Wt.Mean	6494168	17084489	5.347	100.00%	100.00%

Sources: Based on Tables A1, A2, A4, A5 and A6.

The weighted average yield for the whole of this sector 7.845 t/ha falls midway between the high unit area yields of staples and fruit and the lower yield for vegetables. But, as with inputs per unit of production, this average yield is dominated by the high per hectare yields of cassava and sweet potato. However, in this case it is not legitimate to eliminate these crops from our calculations so as to obtain a 'better' estimate of the unit area requirements of non-rice food production. Thus, on average, each tonne of non-rice food production requires 0.127 ha of land area.

In the summary table that follows (Table A8) the estimates of labour and physical inputs used are those from Table A6A, and the unit area yields are from Table a7A.

Natural Resource Inputs/Impacts of Non-Rice Food Production

The heterogeneity of the crops included in this sector - staples, vegetables and fruits - makes it extremely complicated to define generally valid natural resource requirements and impacts. As previously mentioned, many of these crops, particularly the high value vegetable and fruit crops, are grown under fully commercial conditions, with high levels of physical inputs (fertilisers and pesticides) and large amounts of human labour for crop maintenance. We have no means of discriminating between the crop species, or the proportion of a given crop, that are grown under subsistance, semi-subsistance or commercial conditions. In general terms, crops grown under commercial conditions will require less land per unit output than crops grown under semi-subsistance conditions (because of higher yields), but because of more frequent and intensive cultivation, these crops may be responsible for a larger amount of erosion per unit output than non-commercial production.

In terms of natural resource impacts it is generally fair to say the main impact of the crops is on the rate of soil erosion. But even here we have very limited information, and are reduced to making broad estimates. Despite this lack of information, there can be little doubt that the on-site costs of erosion, reduced soil fertility in particular, will result in higher production

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Sources: Based on Tables A1, A2, A4, A5 and A6.

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costs as farmers substitute manufactured fertilisers for natural fertility. Off-site soil erosion leads to the (more rapid) siltation of dams, rivers and harbours - all of these have substantial direct and indirect economic (and social) impacts.

Water - Rainfall and Irrigation

Almost all of these crops are grown under rainfed conditions, thus they have no requirement for irrigation water. However, most of the staple crops (maize, sweet potato, soybean and groundnut) are also grown as secondary crops in rotation with rice, and rely on both rainfall and residual moisture in the unirrigated ricefields for their water supply.

Estimating one figure to represent the water demands and needs of the diverse mix of non-rice food crops is problematic. We have not attempted to make an estimate based on the mix of crops that are grown and the broad rainfall patterns within Indonesia - this would be complex and time consuming exercise beyond the capacities of this study, and the results would be almost impossible to validate. In addition, the very complexity of the methods used might lend a spurious validity to the results. Rather, we have simply used a general figure for evaporation under general Indonesian climatic condition to provide an indication of water requirements per unit of production.

Under monsoonal conditions prevailing in Indonesia (humid tropics, moderate temperatures), evapotranspiration averages 5-6 mm/day (Euroconsult 1989). This is equivalent to 50-60 cubic metres of water per hectare per day. Given a growing season of 100 days for non-rice crops, this is equivalent to a requirement of 5-6,000 cubic m/ha/crop. Note that a significant proportion of this comes from groundwater drawn up the plant, and not from incident rainfall. Using the average yield rate of 7.845 t/ha for non-rice crops, this translates to a water requirement of 637-765 litres/t. Given the higher per unit water requirements for vegetable production, compared to staples or tree crops, we will use the higher figure of 765 lt/t.

Chemical Fertilisers and Biocides

Except for high value commercial crops almost no fertiliser and biocides are employed in non-rice food crop production. Dependance on rainfall for water, low yields and/or the low unit value of output simply makes use of these expensive inputs uneconomic. However, there is intensive use of these inputs in the commercially-orientated production of vegetables (including potatoes) and some fruits for sale in major urban markets.

The amount of fertiliser applied is related both to the need to supply additional major nutrients to make-up for nutrients harvested in the crop itself and to make-up for nutrients lost through soil erosion. There is no data available on the level of nutrients lost in run-off experienced under intensive, commercial vegetable production.

Both by report and by observation large amounts of biocides are frequently applied to high value market garden crops. On the whole these chemicals have low persistence, and their directly toxic effects on non-target organisms is probably minimal beyond the area in which they are applied. However, within the boundaries of the fields in which they are used there can be no doubt that many non-target organisms are killed. As with their use in rice, the long-term use of these chemicals is leading to a loss of species and an unwitting 'simplification' of the ecosystem. As detailed and reliable data on application rates is completely unavailable in the literature, it is not possible to make even a 'ballpark' estimate of the impact on non-target species.

Humans are also a non-target species, and there is a growing amount of evidence that people who consistently work with biocidal chemicals have poorer general health; this is aside from the impact on human health of acute poisoning incidents caused by spillages, equipment failures and/or accidental ingestion by children. In areas in Java and Sumatera where intensive vegetable production is a major agricultural activity and biocides are applied in frequent, large doses, the bulk of the spraying is done by young men (and women) who specialise in this work. These young people are, therefore, exposed almost daily to large intakes (by dermal and respiratory routes) of highly toxic nerve poisons. The qualitative evidence of the negative impact on their health is undeniable, and more work is currently underway to refine early research (Hirshhorn, pers. comm.). However, there is no information available (anywhere) quantifying the economic consequences of these health impacts, let alone relating this to levels of agricultural production. What is clear is that there are and will be negative impacts on human health that have real costs for the individuals, their families and the community. Whether these impacts can be accounted for in the present study is unclear.

Soil Erosion

Probably the most important impact from cultivation of non-rice food crops is soil erosion, both in terms of its local impact in reducing soil fertility (hence agricultural productivity) and the in off-site impacts of siltation of rivers, dams and harbours. In terms of loss of natural fertility, it is generally reckoned that eroded topsoil contains approximately twice the concentration of nutrients as the soil left behind, because nutrients are concentrated in the upper layers of the soil. This means that erosive losses of economically important nutrients is occuring about twice as fast as the general concentration of these nutrients in a given soil type. Reduced productivity is the direct consequence of soil nutrient depletion, forcing farmers to use manufactured fertiliser and other supplements (increasing cost per unit of production) or move their cultivation to another site where nutrients are sufficient (as in slash-and-burn farming).

Increased erosion speeds up river siltation, resulting in shallower rivers (restricting inland navigation) and watercourses that are more prone to flooding after heavy rains; in addition, upland deforestation exacerbates both the frequency and intensity of flooding. In the case of dams, siltation can and has reduced the effective life of major dams by many years; there is already a major programme of dam dredging underway in Java to relieve this problem. Harbour siltation increases the frequency with which dredging must be undertaken and, hence, the overall costs of sea transportation.

Making a summary, quantitative assessment of soil erosion caused by activities in this sector is possible, but beneath the single figure lie many uncertainties. The impact of agricultural activities on rates of soil erosion depend on a range of interacting factors, the main ones being: soil type, degree of slope and length of slope, rainfall (rate, intensity and duration), cultivation practices, amount of ground cover, soil conservation practices. While methods for collecting empirical data on these variables exist, carrying out the measurements is both expensive and time consuming. Moreover, because of non-linear interactions between important factors, results obtained in one location for a given soil type cannot be reliably extrapolated to another area, let alone to another country.

Reasonable approximations at a national-level of agricultural impacts on soil erosion rates require being able to accurately characterise (and quantify) the soil, slope, rainfall pattern and cropping system within relatively small, homogeneous areas. This requires linking a sophisticated computer database of numerical information on these fators to digital maps of the region(s) of interest, developing or using algorithms (such as the Universal Soil Loss Equation) to estimate soil erosion area-by-area and crop-by-crop, and summing this to provide regional and national estimates. For a country like the US, where broad-acre farming is common and digital data and maps are available, this is a major exercise for a highly skilled team with access to substantial financial resources. Little or none of the necessary information (or digital maps) are available in Indonesia; nor, given the small-scale, complex patterns of dryland agriculture, would such an approach work, even if data and maps were available.

Given these limitations, we are forced in this study to make a gross approximation of the soil erosion impact of agriculture for non-rice food production. Euroconsult (1989) provides estimates of soil loss rates caused by water erosion, ranging from 0.24 t/ha/year for natural forests on slopes of 7-15%, up to 89.6 t/ha/yr for bare soil with a slope of 7%, this is more than double the rate for crops with bare soil or fallow on the same slope (43.6 t/ha/yr). In general, soil loss rates on slopes increase exponentially as the slope gets steeper and asymptotically as the slope gets longer. Reported rates of soil erosion in Indonesia (Ambar, pers. comm.) range from a minimum of 0.3 mm/annum to a maximum of 12 mm/annum. In terms of per hectare rates of volumetric loss, these are equal to a range of 3-120 cubic

metres/ha/yr. Assuming that an average type of soil weighs 1.8 t/cubic metre, this translates into rates of 5.4-216 t/ha/yr.

Even from casual observation of the agricultural landscape, it is abundantly clear that in Indonesia cultivation of non-intensive staple crops (maize, cassava and sweet potato, in particular) commonly takes place on slopes far in excess of 7%. In these conditions - with cultivation occuring on slopes up to 25% (sometimes more) and where most of the soil is bare of cover - erosion rates will be well in excess of 90 t/ha/yr. On the other hand, cultivation of maize, soybean or groundnut, for instance, as a secondary crop following irrigated rice in level ricefields will result in minimal erosion; terracing on slopes also reduces erosion, but the degree of reduction depends a great deal on the width and slope of the terrace, the pattern of drainage channels, and the perimeter vegetation that is maintained. In between, in terms of erosion rates, are both intensive vegetable cultivation (which is important econcomically, but relatively minor in terms of total area) and non-intensive cultivation of other non-rice crops on moderately sloping land.

It should be borne in mind that even though it may only be possible to obtain one crop per year from rainfed agriculture in many areas (particularly NTB and NTT) erosion occurs throughout the year whenever there is rainfall. However, with the monsoonal pattern of rainfall in Indonesia, it is clear that the majority of erosion occurs during the rainy season. In order not to unwittingly over-estimate soil erosion per unit of production, estimates of soil losses for non-rice food crop production are based on an average growing period, rather than on losses over a full year. For the purposes of this exercise we assume an average growing period of 100 days for non-rice food crops.

Given that even on moderate slopes of 7% soil losses approach 50 t/ha/yr and on steep slopes exceed 200 t/ha/yr, we have decided, initially, to use an approximation of 100 t/ha/yr to characterise soil losses associated with non-rice food production. Over a full year this translates into approximately 0.274 t/ha/day, 8.22 t/ha/month or 27.4 t/ha/100 days.

Given an average yield of non-rice food crops of 7.845 t/ha/crop and an average growing period of 100 days, one tonne of non-rice food production is estimated to result in the erosion (loss) of approximately 3.492 tonnes of soil and its contained nutrients.

Capital Goods Inputs to Non-Rice Food Production

The general comments for capital goods inputs to rice production also apply to the production of non-rice food crops with equal or greater force. In particular, we are unable to identify the separate value of contributions from buildings and irrigation, because of aggregation in the national financial estimates. or to separate contributions to rice and non-rice food production.

Draft Cattle and Tractors

Reference is made to the comparative estimations in Tables 6A and 6B, which show the downward influence of cassava production on weighted average input levels for the remainder of the sector. Based on the first estimate, a weighted average use of 3.803 days/ha of draft labour using cattle (Table A6A) is required, based on Table A6B (from which inputs to cassava cultivation have been excluded) the weighted average requirement is 5.588 cattle days/ha. We have used the former figure in Table A8 which summarises inputs to production.

The comments regarding the establishment of appropriate weights made for physical inputs also applies to making a decision about which of these two figures to use in further calculations.

It is generally uncommon to use tractors for land preparation with non-rice food crops, thus all draft labour inputs to land preparation for these crops are assumed to come from draft labour supplied by cattle. It should be noted that in almost all areas where non-intensive dryland farming is practiced, cattle manure is an essential ingredient for maintaining soil fertility, albeit at low levels. Thus, even if tractors were available and economic, it would still be necessary to maintain cattle for their role in supplementing soil fertility.

Agricultural Machinery, Buildings and Irrigation Infrastructure

An estimate of the value of capital goods per unit of production for non-rice food crops is given in the foregoing section on capital requirements for rice production. As we are unable to divide this contribution between rice and non-rice food crops due to lack of data, the same figure has been used here: Rp 75,833/tonne.

It should be noted that this figure may be regarded as an overestimate for non-rice crops, as no expenditure on irrigation infrastructure is required. On the other hand, many farmers may have made private, statistically unaccounted for investments in labour intensive erosion-preventing terracing and cultivation practices, the value of which may be captured in this figure.

Summary

Inputs to non-rice food production are summarised below in Table A8. As with inputs to rice production, these are based on the quantities of inputs necessary to produce one tonne of food or the natural resource impacts of producing one tonne of food. The data below include all non-rice food crops, including cassava. As before, it is emphasised that 'one tonne of food' is heterogeneous in composition.

Table A8:
Summary of Inputs to Non-Rice Food Production per Tonne of Output in 1985.

Input	From sector	Quantity
Seed (kg)	2	5.839
Urea (kg)	45	15.122
Other fertilisers (kg)	45	17.769
Pesticides (kg)	45	0.095
Human labour (person-years)		0.0806
(person-days)		24.181
Draft Labour (cattle-days)	18	3.803
Tractors (machine-days)	56	0.0
Natural resources		
Land required (ha)		0.127
Water required (cubic metres)		0.765
Soil loss (tonnes/tonne output)		3.492
Capital (Rp/t)	various	75,833

Notes: Person-year = 300 working days.
Sources: Various tables this report.

Prospects for the year 2020.

Introduction.

Three factors make developing a coherent and consistent non-rice food production scenario for the year 2020 difficult. First, as with the I-O situation for 1985, there is the problem of hetreogenity of products, production methods and biophysical conditions. Second, there may be major, but unanticipated, increases in the productivity of major crops as a result of advances in biotechnology. Third, it is apparent that the rate and degree of environmental degradation being caused by current farming methods, particularly on sloping and/or newly cleared land, is liable to result in many radical, albeit local, declines in food production capacity long before the year 2020.

In the previously developed scenario for rice production, we used population forecasts for the years to 2020 to estimate likely demand. A similar procedure is employed in this case. The data developed by RePPProT on the possibilities and limitations on land suitable for agriculture will be used to set bounds on the areal extent of dryland agricultural production.

There are two recent modelling exercises which have been used to help parameterise the non-rice food crop sector scenario for the year 2020. One produced by Winrock International (WI) by Fletcher and Altemeir (1991) under the auspices of BAPPENAS, and the other by the Centre for World Food Studies (SOW) under a contract to the World Bank (SOW 1991). Both studies used econometric methods and general equilibrium models to develop scenarios.

Rates of Change

Both the WI and SOW models are in agreement that production in the food crops sector will grow at a much slower rate than either the estate and livestock sectors. And, within the crop sector the most rapid growth will be in crops grown for stock feed and further processing: maize, cassava and soybean. In addition, within the food crops sector, the SOW model estimates that production of vegetables and fruit will increase faster than production of staple crops, particularly rice.

These two scenarios are described below, with particular emphasis on the conclusions that are drawn for staple crop production, land availability and natural resource impacts.

WI Scenario

The WI study developed two scenarios: the first where rice prices were kept at import parity, i.e. about 25-30% above world market prices - this is their *status quo* scenario; the second where rice prices declined to world prices by about 1994 - the *diversification* scenario. These changes were achieved by altering the levels of investment for improvement and expansion of irrigation.

Status Quo Scenario

Rice production - assuming a high GDP growth rate (6% p.a.) and an average income elasticity for rice of 0.1 - increases at 0.68% p.a., and is sufficient to maintain trend self-sufficiency in rice; average per capita consumption is constant at about 143 kg per annum, reaching saturation in the early-1990s. The difference in area expansion and yield increases between Java and the rest of Indonesia (off-Java) is worthy of note, and the off-Java trend is a general characteristic of changes in the location of agricultural production and productivity increases, especially for tree crops, with the possible exception of livestock (poultry, in particular).

For secondary crops over 1991-2000, maize production increases at 3.91% p.a., cassava at 3.46% p.a. and soybean at 5.57% p.a.; for maize and cassava the increases result from increased productivity, for soybean from areal expansion. Tree crop production (rubber. palmoil, coconut, tea, coffee and sugar) grows by between 3.01% and 6.37% p.a. over 1991-2000. Under this scenario, despite increasing demand for livestock feed, Indonesia becomes a net exporter of maize (about 266,000 tonnes p.a.) and cassava (3.4 million tonnes p.a.), but remains a major importer of soymeal (0.829-1.221 million tonnes p.a.). The general effect of these surpluses available for export is to force domestic prices down to export parity level.

Over this period, in the *status quo* scenario, use of fertilisers for food crops is estimated to decline (-1.22% p.a. for urea, -1.01 % p.a. for TSP and -1.13% for other types). This is directly related to the removal of fertiliser subsidies in the early 1990s (this contrasts sharply with estimated use of fertiliser in the SOW model). However, use of fertiliser for tree crops is estimated to increase rapidly, at 5.09% p.a. for all types of fertiliser. Overall, fertiliser use declines by an average of 0.15% p.a. in absolute terms, despite the increase in cropped area and yields.

Labour use in agriculture (including livestock and fisheries) is estimated to increase at 1.14% p.a. for the 1991-2000 period. However, labour use in food crop production is expected to decline at -1.45% p.a. nationally (-1.71% on-Java and -0.06% off-Java); average labour use for primary processing (rice milling, sugarcane, cassava, coffee, tea and slaughtering) is estimated to increase at 3.24% p.a.. Given the increases in food crop production over this period, changes in food crop labour use imply rapidly rising labour productivity - more than 2% p.a. (unfortunately, the data do not allow disaggregation of rice and non-rice food crop productivity).

Diversification Scenario

The major difference between this and the former scenario is that rice prices decline by 10% p.a. over 1992-95. To prevent a substantial decline in rice production, the decline in prices is

compensated for by an increase in investment in irrigation, mostly directed to upgrading or rehabilitating existing systems. Total rice supply increases by 1.25% p.a., the fall in price leads to a slight increase in demand (0.12% p.a.), and per capita consumption reaches 147 kg per annum by the year 2000; they also project minor exports of rice (232,000 tonnes p.a.).

Under this scenario non-rice food crop production increases at the same rates as under the former scenario: maize 3.93% p.a., cassava 3.46% p.a. and soybean at 5.64% p.a. over 1991-2000. Exports of maize average one million tonnes p.a. and cassava 4 million tonnes p.a.. Given difficulty in marketing this volume of cassava (due to quotas), domestic prices are likely fall and farmers may switch to soybean production, thus helping reduce the level of imports from an estimated average of 1.55 million tonnes p.a..

With this scenario over 1991-2000, fertiliser use on food crops declines more rapidly than in the previous scenario: urea use at 2.37% p.a., TSP at -2.63% p.a. and other fertiliser at -2.39% p.a.. Overall, total fertiliser use declines at an average of -1.18% p.a..

Labour use in agriculture overall declines more slowly than in the previous scenario (-0.76% p.a. nationally, -1.07% on-Java and 0.27% off-Java), and labour use in food crop production also declines more slowly (-1.71% p.a. nationally, -0.61 on-Java and -1.45% off-Java). Labour absorption in first stage processing grows more rapidly (4.53% p.a.) than in the first scenario.

The difference between these two scenarios, with regard to labour use in food crop production is notable, and implies a slower growth in labour productivity in the second scenario. Reflecting this decline in productivity, the authors comment that real rural wages decline by 2.2% p.a. over the decade (in line with falling rice prices), with significant negative implications for rural poverty alleviation.

Changes in Food Production Technological Coefficients

In this summary of changes in staple food production the results of the *diversification* scenario have been used, rather than those from the *status quo* scenario. The reasons for this are as follows.

There is increasing evidence that the former agricultural development strategy focusing narrowly on rice production is shifting to one that encourages diversification of food crop production; this shift also includes encouragement for a more rapid expansion of livestock production. The evidence comes from numerous public statements by senior government officials, including the President, and from detailed discussions by the author with line officials in various directorates within the Department of Agriculture. Most recently, the further reduction in fertiliser subsidies (the bulk of which have been for rice cultivation),

indicates that the general economic incentives to farmers for increasing rice production are being reduced.

The *diversification* scenario was developed explicitly to examine the implications of this shift in policy over the 1990-2000 period. In this scenario, annual per capita rice consumption only increases by about 1 kg over the study period, whereas there are substantial increases in the amount of soybean (6.72 kg) and meat (poultry 0.56 kg and beef 1.13 kg) consumed per capita.

The estimated impact of this scenario on three major staple food crops is summarised below.

Maize production

Over the study period maize production is estimated to increase from 7.2 to 10.2 million tonnes, and average yields to increase from 2.1 t/ha to 2.8 t/ha; with yield increasing by 3.93% p.a.. This implies a reduction in the area needed to grow one tonne from 0.47 ha to 0.36 ha by the year 2000.

Cassava Production

Cassava production is projected to increase from 16.9 to 22.9 million tonnes, and yields from 12.9 t/ha to 17.1 t/ha, equivalent to a yield increase of 3.46% p.a.. This increase in yield will reduce the land area needed to grow one tonne from 0.08 ha to 0.06 ha.

Soybean Production

The production of soybean is expected to increase from 1.39 to 2.3 million tonnes by the year 2000, and yields to increase from 1.1 t/ha to 1.4 t/ha. This will reduce the area required to grow a tonne from 0.87 ha to 0.71 ha.

Natural Resource Implications

The WI scenarios do not concern themselves with the natural resource implications of the changes envisaged. Foremost among these are the impacts of increased agricultural production on land resources, and on whether there will be sufficient suitable land to support the increases in production envisaged. Nor, in making their estimates of increases in food crop yields, are the effects of soil erosion, declining soil fertility, or declining water quality and availability for agriculture addressed, even in passing. In addition, adverse effects on water quality, in particular, the rising volume of (untreated) discharges from food (and tree) crop processing plants do not receive mention, despite the rapid expansion estimated for these activities.

Land Resources

The harvested area of dryland crops (rice, maize, cassava and soybean) is expected to expand by some 806,000 ha by the year 2000. Given that only one crop per year is usually harvested, this implies an expansion in dryland agricultural area of about the same magnitude.

Although tree crops are not the focus here, it is clear that a major expansion in area is anticipated, with total area growing from 8.9 to 13.5 million ha by the year 2000, an increase of some 4.6 million ha.

These areas can be compared with estimates of the *maximum* extent of area recommended for agricultural development, as estimated by RePPProT (1990) (see Table A9 below). The RePPProT study estimated that, on the basis of experience, an average only 35% of the potential area suitable for wetland or dryland arable crop expansion is found to be suitable after detailed surveys are completed. This area is referred to in the discussion that follows as the *minimum* potential area for expansion. The comparisons that follow are, thus, optimistic indeed, if account is taken of these factors.

For dryland arable crops, with an assumed increase in area of 806,000 ha, some 28% of the 2.86 million ha of potentially suitable land will be required. For tree crops, where a major expansion in area is envisaged, some 59% of the maximum potential area of 7.64 million ha will be required.

In total, the expansion and diversification of agriculture contemplated by this WI scenario will require an increase in agricultural area of at least 6 million ha by the year 2000. This is some 40% of the total of 15 million ha - the *maximum* area technically suitable for agricultural expansion according to the RePPProT study. It is apparent that by the year 2000 this envisaged expansion in agriculture will require that almost all the *minimum* potentially suitable land be brought into full production.

SOW Scenario

The SOW study, in contrast to the WI study, begins with an assessment of the available resources and the general impacts of increasing economic activity on the availability and quality of essential inputs: land, soil and water. They begin development of their scenario (and model) with an overview of the trends in the use and availability of natural resources (land, water and soil) and the potential for increases in crop yields and agricultural intensification.

The SOW (1991) study presumes that the Indonesian economy will grow by 6-7% p.a. over the period 1900 to 2010. This is, as they state, a deliberately optimistic presumption and a growth rate that will be difficult to sustain over 20 years. The total population in 1990 is

estimated as 181.2 million people, by the year 2000 (they estimate) it will have grown to 211 million and by 2010 to 234 million (an increase of 53 million or 29.3%). During this period they estimate the size of the population will increase initially at 1.9% p.a., declining to 1.5% p.a. by the year 2000, and declining further to 0.9% by the year 2010. They estimate the labour force participation rate will rise from 43% (1990) to 55% by the year 2010, an average rate of some 2.5% p.a..

SOW use their applied general equilibrium model to estimate requisite changes in production and productivity: a steady growth of 2% p.a. in direct consumption of agricultural products, which they estimate will require a general increase in labour productivity of 4% p.a. to achieve a 6% growth rate. This is, indeed, optimistic given past increases in labour productivity (1.0% p.a.), particularly for agricultural productivity, which increased by an average of only 0.5% p.a. over the last 10-15 years; as against 2.0% p.a. in manufacturing and mining.

In dealing with this issue the SOW study was mainly concerned with the negative impact of soil erosion on crop yields; they draw largely on the work by Repetto et al (1989). The bulk of the erosion, according to Repetto et al, takes place as a result of dryland (*tegal*) farming on slopes. Repetto et al estimated that soil erosion reduces yields for erosion-sensitive crops such a maize and soybeans by some 6.8% p.a., and for less sensitive crops like cassava yield losses may amount to 4.4% p.a. The SOW study notes, despite this, that yields of dryland crops have continued to increase steadily over the last 10-15 years. In terms of the relative economic impacts of erosion, Repetto et al suggest that on-site costs in terms of foregone income outweigh off-site costs in the ratio of 5-6:1.

Yield Increases and Intensification

Potential on-Java

For maize, yield increases have averaged 4.1% p.a. over 1970-90, raising production to 2.3 t/ha, but potential for increased yields is still great. Yield increases for soybean have also been significant at about 2% p.a., again there is room for improvement. With cassava, they do not expect any substantial improvements in yields, given the dryland conditions under which it is grown and the fact that other crops offer better returns to farmers. For non-rice crops, both on-Java and off-Java, they do not anticipate any significant increases in cropping intensity, as cultivation depends on rainfall rather than land availability.

Potential off-Java

The SOW study notes that, generally, yields for arable crops off-Java are 20-30% lower than on-Java for the same crop, largely due to less advanced and more extensive production techniques. Thus, the potential for yield increases are, theoretically, much greater than off-

Java. The study comments that returns from devoting resources to improving yields off-Java should have priority over extension of the area of agricultural land or further intensification on-Java. Overall, they conclude that yield increases for both rice and other crops could be much more rapid off-Java than they have been to-date, given sufficient support, but they provide no separate estimates, except model outputs, of what may be achievable.

Summary of Agricultural Assumptions for the SOW Model

For maize, yield increases average 3.0% p.a. and 2.3% p.a. for cassava. For the other major dryland crops, excluding vegetables, yield increases are set at 2% p.a. or less. For vegetables higher rates of yield increase are used, 6.5% p.a. until the year 2000 and 6.4% thereafter.

In sharp contrast to the WI study, rates of fertiliser and pesticide use - set to increase at 0.8% p.a. over the whole period - are assumed to increase more rapidly than yields. Labour productivity in agriculture is assumed to increase slowly, as the employment-output elasticity is set at only 0.32 over the whole period; wage increases in agriculture will, however, still lag behind other sectors of the economy.

Increases in Agricultural Land Use

The most rapid increase in harvested area is in the cash crop sector, both smallholder and estate; expansion of dryland food crop harvested area is much slower. Overall, dryland harvested area increases by 9.3 million ha over the whole period. The expansion of dryland area for food, smallholder cash and estate crops (2.2, 5.3 and 1.8 million ha, respectively), requires some 76% of the *maximum* additional land potentially available for dryland agriculture, as estimated by RePPProT (see Case Study No.6, Table A8). The sum of these area is greater than the *minimum* area available (after applying the 35% and 70% factors) of 8.7 million ha.

Table A9:
Estimated Land Use and Harvested Area: Indonesia 1990 and 2010.

million ha	Java 1990	Java 2010	Off-Java 1990	Off-Java 2010	Indonesia 1990	Indonesia 2010
Wetland area	3.4	3.1	5.1	6.3	8.5	9.4
Harvested area					12.307	14.964
rate of increase		1900-2000	1.5%		2000-2010	0.6%
Dryland food crops					7.115	9.356
rate of increase		1990-2000	0.4%		2000-2010	2.2%
Dryland cash crops					7.328	12.613
rate of increase		1990-2000	3.3%		2000-2010	2.3%
Estates					1.134	2.889
rate of increase		1990-2000	4.5%		2000-2010	5.0%
Total Harvested Area					36.384	49.222

Notes: Dryland cash crops are those produced by smallholders.
Source: SOW 1991.

Increases in Crop Production

Table A10 illustrates the massive increases in food production that the SOW model projects for the year 2010. Of particular note is the scale of the increase in non-rice staple food production: rice (47%), maize (141%) and cassava (115%) and roots and tubers (56%) - an overall increase of 74% in production. This increase needs to be set against their estimated increase in population for the same period: from 181 to 234 million people, an increase of 29.3%. Even accepting that an increasing proportion of staples such as maize and cassava will be used a animal feedstuffs, and increasing exports of these two crops, the growth in projected food production, particularly for rice, may well be excessive in relation to population size.

Table A10:
Estimated Increases in Food Crop Production 1990 to 2010.

x 1000 t	Prod'n 1990	Prod'n 2010	1990-2010	Increase 1990-2010	Rate 1990-2000	Rate 2000 2010
Rice	42,148	61,916	19,768	46.9%	2.3%	1.7%
Maize	6,567	15,811	9,244	140.8%	3.9%	5.0%
Cassava	18,116	38,932	20,816	114.9	3.7%	4.1%
Roots & Tubers	3,370	5,256	1,886	55.9%	2.6%	2.0%
Vegetables	7,051	24,671	17,620	249.9%	6.5%	6.4%
Beans & Nuts	1,939	3,139	1,200	61.9%	2.0%	2.8%
Fruit	5,942	10,337	4,895	82.4%	3.5%	2.7%
Staple foods	**70,201**	**121,915**	**51,714**	**73.7%**	**2.8%**	**2.8%**

Notes: Staple foods include: rice, maize, cassava, roots & tubers.
Source: SOW 1991.

Changes in Food Production Technological Coefficients

The results of the SOW study were used to derive technological coefficients for staple crop and vegetable production for the year 2010. The lack of data on inputs for most crops meant that detailed estimates of rates of labour use, and fertiliser and pesticide use cannot be directed estimated for most crops.

For the non-rice food crops, increases in yields are for dryland production by smallholder farmers, who are responsible for the great majority of production in each crop category; this means that yield change estimations are for dryland only. It is not possible to calculate overall yields for these crops, due to inconsistencies in the way the data is presented in the SOW study. The question of whether rates of increase in yields can be maintained in the next ten years to 2020 is dealt with later.

Maize Production

Maize yields over 1990-2010 are estimated to increase from an average of 2.1 to 3.8 t/ha, an increase of 81%; over the study period yield increases at 3.0% p.a.. This improvement in yield implies a decrease in the area need to grow one tonne of maize from 0.47 ha to 0.26 ha.

Unfortunately, the SOW study provides no estimates of changes in fertiliser or pesticide use over the study period, but it is clear that increases, such as those above, are likely to require substantial increases in use, particularly for maize grown on eroding upland soils with declining natural fertility.

Cassava Production

The gradual improvement in cassava yields over the study period results in yields increasing from an average of 12.8 t/ha in 1990 to 20.8 t/ha by 2010, an increase of 63%; average yield increases at 2.6% over the 20 year period. This increase means that the area of land needed to grow one tonne of cassava declines from 0.08 to 0.05 ha over the study period.

This level of average yield is certainly close to the practical maximum that could be reasonably expected for cassava, unless either the growing period is longer than normal (resulting in lower quality) or inputs of fertiliser become much more common.

Roots and Tubers, Vegetables and Fruit

No details of what is included in the 'roots and tubers' group of crops is provided in the study, but it is reasonable to assume that the bulk of the tuber production is sweet potato. Vegetables and fruits are also a diverse pair of crop groups, and no detailed information on their composition or the most important species is provided. Information on the change in area harvested over the study period is not given, hence yields and unit area land requirements for these crop groups cannot be calculated.

Beans and Nuts

The main components of this crop group are probably groundnuts and soybean, but including other leguminous species, i.e. various green beans; it certainly does not include nuts such as walnuts and almonds. Yields for this crop group increase from 993 kg/ha in 1990 to 1.5 t/ha in 2010, an increase of 49%; in the first decade; yields increase at 0.6% p.a in the first decade and by 2.0% p.a. in the second. Thus, the area required to grow one tonne declines from 1.0 ha in 1990 to 0.7 ha by 2010.

Summary of Technological Inputs Factors: WI and SOW Studies.

Below the various input factors for each of the main inputs variables for production of non-rice staple food crops is summarised. As is clear from the above, not all crop categories are commensurable. It should be remembered that the WI study has a time horizon of the year 2000, and the SOW study a horizon of the year 2010.

Land Requirements

Projections of unit area crop yields from both these studies has been used to compile the following table (Table A11).

Table A11:
Land Requirements for Non-Rice Staple Crop Production.

Scenario	WI	SOW
Year	2000	2010
Maize	0.3595	0.2630
Cassava	0.0586	0.0482
Soybean	0.7110	-
Beans and Nuts	-	0.6775

Units: ha/t.
Sources: WI (1992) and SOW (1991).

NRMP Non-Rice Food Crop Production Model

In the current I-O model, we are not making regional distinctions, even at the basic level of on/off-Java, thus these differences are submerged in what follows. However, in making more refined calculations about chages in average national yields, the on/off Java distinction might prove useful.

The nub of the problem is this: Is it reasonable to assume for the period 1990 to 2020 that yields will continue to steadily increase, particularly in the light of recent experience? This author is of the opinion that, based on the evidence of the last 10-15 years, any assumptions about major and steady increases in yields should err on the side of caution, for the following reasons.

Declines in soil quality are likely to have increasingly adverse effects on yield potential. This is likely to lead to decreased agricultural stability in production from year-to-year and lowered resilience to pests and water stress, particularly for dryland food crops grown under marginal rainfall conditions. If the policy of diversifying agricultural production is to be effective, there will need to be a shift of human and other resources away from irrigated rice to other arable and tree crops (subsistence and cash).

The projected decline in the rate of yield increases over time in the WI projections implicitly recognises the impact of these factors; the SOW study assumes that yield increases will remain constant over 1990-2010.

A simple model (similar to the one used for rice) incorporating changes in area harvested, yields, total production, population and per capita consumption was constructed for the period 1985 to 2020 for the main non-rice crops: maize, cassava, sweet potato, groundnut and soybean (vegetables an fruit). Rates of increase in area harvested and yields for each decade over 1990 to 2020 were adjusted so that total production and per capita availability for each crop, and for their combined production in the year 2020, were within reasonable bounds.

Based on this model, total harvested area for these crops increases at 1.47% p.a. over 1985-2020, with a cumulative increase of 67% in area harvested to 9 million ha. Yields increased at 1.21% p.a. (53% net over the study period), to an average of 6.2 t/ha. Total, combined production increased at 2.71% p.a., to 55.9 million tonnes by 2020, an increase of 155% over 35 years. The Indonesian population was estimated to have increased to about 273 million (an average rate of 1.14% p.a.). Consumption of these staples increased at an average rate of 1.14% p.a. to 0.221 t/capita, an increase of 66% over the period.

These rates of increase in production are low, compared to those projected in both the WI and SOW studies. There are two reasons for the difference. First, increases in the area harvested have been constrained to within what is likely to be available, based on the RePPProT data. Second, increases in production in this model have been scaled to meet estimated domestic demand (based on population growth) with no explicit allowance for exports. A rough allowance, however, has been made for the increasing use of maize as an animal feedstuff and in processed food, and for use of processed groundnut and soybean. The production of cassava and sweet potato combined remain almost stable on a per capita basis, as both are increasing substituted for, and export markets are limited. With cassava, a very small and slow increase in production results in quantities judged to be adequate for use as a feedstock for livestock and processed foods.

Based on the RePPProt data the *maximum* extent of land suitable for extension of dryland agriculture is estimated as 2.86 million ha for arable crops and 1.71 million ha for mixed tree and arable crops - the *minimum* (practiable) extent of suitable land at 1.0 and 1.2 million ha, respectively. In 1985 some 5.3 million ha of staple dryland crops, 1.8 million ha of vegetables and 0.6 ha of fruit were harvested - a total area of 7.8 million ha. By 1990, staple crop production had expanded to some 6.7 million ha, a growth rate of 5.3% p.a..

When the additional area of land potentially suitble for arable crops is compared with what appears to be required, even with rates of growth in harvested area set much lower than those of the 1985-90 period, the additional area required is some 3.7 million ha, 1.2 million ha of which would be on-Java and the remainder off-Java. This is greater that the *minimum* extent of feasible expanasion estimated by RePPProt by some 1.5 million ha, before allowance is made for vegetables and fruit crops.

The factor that has most direct influence on changes in technological, labour and natural resource coefficients is yields. In the fairly conservative scenario developed here, averaged yields for five main staple crops increases at 1.21% p.a. over 1985-2020, although maize yields, for instance, increase at 3.16% p.a..

ANNEX 3: OTHER FOOD CROPS (SECTOR 2) - PROJECTIONS 1985-2020.

(based on NRMP and World Bank (1992) estimates)

MAIZE	1985 x 1000	1985-90 rate p.a.	1990 x 1000	1991-2000 rate p.a.	2000 x 1000	2001-2010 rate p.a.	2010 x 1000	2011-2020 rate p.a.	2020 x 1000	1985-2020 net	1985-2020 rate p.a.	1985-2020 %d land
ON-JAVA												
Harv'd Area (ha)	1,493	5.44%	1,947	0.75%	2,098	0.50%	2,205	0.25%	2,261	51%	1.19%	
Yield (kg/ha)	1.923	3.73%	2.310	2.50%	2.957	2.00%	3.305	1.50%	4.183	118%	2.25%	-54.0%
Prod'n (t)	2,872	9.38%	4,497	3.27%	6,203	2.51%	7,948	1.75%	9,457	229%	3.46%	
OFF-JAVA												
Harv'd Area (ha)	946	5.07%	1,212	0.50%	1,274	0.50%	1,339	0.50%	1,407	49%	1.14%	
Yield (kg/ha)	1.540	3.70%	1.846	3.00%	2.481	2.50%	3.176	2.00%	3.871	151%	2.67%	-60.2%
Prod'n (t)	1,457	8.95%	2,237	3.51%	3,160	3.01%	4,252	2.51%	5,449	274%	3.84%	
INDONESIA												
Harv'd Area (ha)	2,440	5.30%	3,159	0.65%	3,372	0.50%	3,544	0.35%	3,668	50%	1.17%	
Yield (kg/ha)	1.774	3.74%	2.132	2.68%	2.777	2.17%	3.443	1.67%	4.064	129%	2.40%	-56.3%
Prod'n (t)	4,330	9.24%	6,734	3.35%	9,363	2.68%	12,200	2.02%	14,906	244%	3.60%	
Population	164,630	1.84%	180,384	1.82%	216,100	1.31%	246,100	1.04%	273,000	66%	1.46%	
Consump.(t/cap/y)	0.026	7.26%	0.037	1.50%	0.043	1.36%	0.050	0.97%	0.055	108%	2.11%	

CASSAVA	1985 x 1000	1985-90 % p.a.	1990 x 1000	1991-2000 % p.a.	2000 x 1000	2001-2010 % p.a.	2010 x 1000	2011-2020 % p.a.	2020 x 1000	1985-2020 net	1985-2020 % p.a.	1985-2020 %d land
ON-JAVA												
Harv'd Area (ha)	830	-0.70%	802	-0.50%	762	-1.00%	689	-1.00%	624	-25%	-0.82%	
Yield (kg/ha)	11.196	2.23%	12.500	0.50%	13.139	0.50%	13.811	0.50%	14.518	30%	0.75%	-22.9%
Prod'n (t)	9,297	1.51%	10,020	0.00%	10,017	-0.51%	9,523	-0.51%	9,053	-3%	-0.08%	
OFF-JAVA												
Harv'd Area (ha)	461	2.01%	510	-0.50%	485	-1.00%	438	-1.00%	396	-14%	-0.43%	
Yield (kg/ha)	10.316	2.02%	11.400	0.50%	11.983	0.50%	12.596	0.50%	13.240	28%	0.72%	-22.1%
Prod'n (t)	4,760	4.07%	5.810	0.00%	5,808	-0.51%	5,522	-0.51%	5,249	10%	0.28%	
INDONESIA												
Harv'd Area (ha)	1,292	0.30%	1,311	-0.50%	1,247	-1.00%	1,128	-1.00%	1,020	-21%	-0.67%	
Yield (kg/ha)	10.881	2.10%	12.072	0.50%	12.690	0.50%	13.339	0.50%	14.021	29%	0.73%	-22.4%
Prod'n (t)	14,057	2.40%	15,830	0.00%	15,826	-0.51%	15,044	-0.51%	14,302	2%	0.05%	
Population	164,630	1.84%	180,384	1.53%	210,065	1.11%	234,697	0.76%	253,156	54%	1.24%	
Consump.(t/cap/y)	0.085	0.55%	0.088	-1.51%	0.075	-1.60%	0.064	-1.26%	0.056	-34%	-1.17%	

SWT POTATO	1985 x 1000	1985-90 % p.a.	1990 x 1000	1991-2000 % p.a.	2000 x 1000	2001-2010 % p.a.	2010 x 1000	2011-2020 % p.a.	2020 x 1000	1985-2020 net	1985-2020 % p.a.	1985-2020 %d land
ON-JAVA												
Harv'd Area (ha)	97	-0.62%	94	**-1.00%**	85	**-1.50%**	73	**-2.00%**	59	-38%	-1.38%	
Yield (kg/ha)	9.028	2.87%	10.400	**0.50%**	10.932	**0.25%**	11.208	**0.25%**	11.492	27%	0.69%	-21.4%
Prod'n (t)	871	2.23%	973	-0.51%	925	-1.25%	815	-1.76%	683	-22%	-0.69%	
OFF-JAVA												
Harv'd Area (ha)	160	-6.38%	115	**-4.00%**	76	**-3.50%**	53	**-3.00%**	39	-75%	-3.92%	
Yield (kg/ha)	8.085	1.48%	8.700	**0.25%**	8.920	**0.25%**	9.145	**0.25%**	9.377	16%	0.42%	-13.8%
Prod'n (t)	1,290	-5.00%	998	-3.76%	681	-3.26%	489	-2.76%	369	-71%	-3.51%	
INDONESIA												
Harv'd Area (ha)	256	-4.04%	208	-2.55%	161	-2.40%	126	-2.41%	99	-61%	-2.68%	
Yield (kg/ha)	8.440	2.31%	9.463	0.53%	9.978	0.35%	10.335	0.30%	10.649	26%	0.67%	-20.7%
Prod'n (t)	2,162	-1.82%	1,971	-2.03%	1,606	-2.06%	1,304	-2.12%	1,052	-51%	-2.04%	
Population	164,630	1.84%	180,384	1.82%	216,100	1.31%	246,100	1.04%	273,000	66%	1.46%	
Consump.(t/cap/y)	0.013	-3.60%	0.011	-3.79%	0.007	-3.32%	0.005	-3.13%	0.004	-71%	-3.44%	

GROUNDNUT	1985 x 1000	1985-90 % p.a.	1990 x 1000	1991-2000 % p.a.	2000 x 1000	2001-2010 % p.a.	2010 x 1000	2011-2020 % p.a.	2020 x 1000	1985-2020 net	1985-2020 % p.a.	1985-2020 %d land
ON-JAVA												
Harv'd Area (ha)	337	4.53%	420	**1.00%**	464	**0.50%**	488	**0.25%**	500	49%	1.14%	
Yield (kg/ha)	1.020	0.56%	1.049	**1.00%**	1.159	**0.75%**	1.249	**0.50%**	1.313	29%	0.72%	-22.3%
Prod'n (t)	344	5.11%	441	2.01%	538	1.25%	609	0.75%	657	91%	1.87%	
OFF-JAVA												
Harv'd Area (ha)	173	4.40%	215	**2.00%**	262	**0.15%**	266	**1.00%**	294	70%	1.52%	
Yield (kg/ha)	1.064	-1.71%	0.976	**0.75%**	1.052	**0.50%**	1.106	**0.25%**	1.133	7%	0.18%	-6.1%
Prod'n (t)	184	2.61%	210	2.77%	275	0.65%	294	1.25%	333	81%	1.70%	
INDONESIA												
Harv'd Area (ha)	510	4.48%	635	1.35%	726	0.38%	754	0.52%	794	56%	1.27%	
Yield (kg/ha)	1.035	-0.21%	1.024	0.90%	1.120	0.68%	1.198	0.39%	1.246	20%	0.53%	-17.0%
Prod'n (t)	528	4.27%	651	2.26%	813	1.05%	903	0.92%	990	87%	1.81%	
Population	164,630	1.84%	180,384	1.82%	216,100	1.31%	246,100	1.04%	273,000	66%	1.46%	
Consump.(t/cap/y)	0.003	2.38%	0.004	0.43%	0.004	-0.25%	0.004	-0.12%	0.004	13%	0.35%	

SOYBEAN	1985 x 1000	1985-90 % p.a.	1990 x 1000	1991-2000 % p.a.	2000 x 1000	2001-2010 % p.a.	2010 x 1000	2011-2020 % p.a.	2020 x 1000	1985-2020 net	1985-2020 % p.a.	1985-2020 %d land
ON-JAVA												
Harv'd Area (ha)	582	4.52%	726	2.00%	885	1.50%	1,027	1.00%	1,134	95%	1.93%	
Yield (kg/ha)	1.019	3.39%	1.204	4.00%	1.782	3.00%	2.395	2.00%	2.920	186%	3.05%	-65.1%
Prod'n (t)	593	8.06%	874	6.08%	1,577	4.54%	2,459	3.02%	3,311	458%	5.04%	
OFF-JAVA												
Harv'd Area (ha)	314	14.10%	608	5.00%	991	3.00%	1,331	2.00%	1,623	416%	4.80%	
Yield (kg/ha)	0.880	2.78%	1.009	3.50%	1.423	3.00%	1.913	2.50%	2.449	178%	2.97%	-64.1%
Prod'n (t)	277	17.27%	614	8.67%	1,410	6.09%	2,547	4.55%	3,974	1336%	7.91%	
INDONESIA												
Harv'd Area (ha)	896	6.28%	1,334	3.47%	1,875	2.32%	2,358	1.58%	2,757	208%	3.26%	
Yield (kg/ha)	0.970	2.82%	1.115	3.63%	1.593	2.92%	2.123	2.21%	2.642	172%	2.90%	-63.3%
Prod'n (t)	870	11.33%	1,487	7.22%	2,987	5.30%	5,006	3.82%	7,285	738%	6.26%	
Population	164,630	1.84%	180,384	1.82%	216,100	1.31%	246,100	1.04%	273,000	66%	1.46%	
Consump.(t/cap/y)	0.005	9.31%	0.008	5.30%	0.014	3.94%	0.020	2.75%	0.027	405%	4.74%	

STAPLE CROPS	1985 x 1000	1985-90 % p.a.	1990 x 1000	1991-2000 % p.a.	2000 x 1000	2001-2010 % p.a.	2010 x 1000	2011-2020 % p.a.	2020 x 1000	1985-2020 net	1985-2020 % p.a.	1985-2020 %d land
ON-JAVA												
Harv'd Area (ha)	3,339	3.62%	3,988	0.74%	4,294	0.43%	4,482	0.21%	4,578	37%	0.91%	
Yield (kg/ha)	4.186	0.13%	4.214	0.63%	4.486	0.61%	4.765	0.60%	5.059	21%	0.54%	-17.3%
Prod'n (t)	13,977	3.75%	16,804	1.37%	19,260	1.04%	21,355	0.82%	23,161	66%	1.45%	
OFF-JAVA												
Harv'd Area (ha)	2,055	5.29%	2,659	1.50%	3,087	1.05%	3,428	0.93%	3,760	83%	1.74%	
Yield (kg/ha)	3.877	-0.87%	3.711	-0.11%	3.671	0.40%	3.822	0.68%	4.089	5%	0.15%	-5.2%
Prod'n (t)	7,968	4.37%	9,869	1.39%	11,335	1.46%	13,103	1.61%	15,374	93%	1.90%	
INDONESIA												
Harv'd Area (ha)	5,394	4.27%	6,647	1.05%	7,381	0.69%	7,910	0.53%	8,338	55%	1.25%	
Yield (kg/ha)	4.068	-0.28%	4.013	0.32%	4.145	0.50%	4.356	0.59%	4.622	14%	0.36%	-12.0%
Prod'n (t)	21,946	3.98%	26,673	1.38%	30,595	1.20%	34,458	1.12%	38,535	76%	1.62%	
Population	164,630	1.84%	180,384	1.82%	216,100	1.31%	246,100	1.04%	273,000	66%	1.46%	
Consump.(t/cap/y)	0.133	2.10%	0.148	-0.43%	0.142	-0.11%	0.140	0.08%	0.141	6%	0.16%	

VEGETABLES	1985 x 1000	1985-89 % p.a.	1989 x 1000	1990-2000 % p.a.	2000 x 1000	2001-2010 % p.a.	2010 x 1000	2011-2020 % p.a.	2020 x 1000	1985-2020 net	1985-2020 % p.a.	1985-2020 %d land
ON-JAVA												
Harv'd Area (ha)	170	2.51%	187	2.00%	233	2.00%	284	2.00%	346	104%	2.06%	
Yield (kg/ha)	8.177	5.84%	10.261	2.50%	13.463	2.00%	16.411	1.50%	19.046	133%	2.45%	-57.1%
Prod'n (t)	1,388	8.49%	1,923	5.02%	3,137	4.04%	4,662	3.53%	6,595	375%	4.55%	
OFF-JAVA												
Harv'd Area (ha)	91	2.89%	102	3.00%	141	2.50%	180	2.00%	219	142%	2.56%	
Yield (kg/ha)	5.457	8.87%	7.668	2.50%	10.061	2.00%	12.264	2.00%	14.950	174%	2.92%	-63.5%
Prod'n (t)	494	12.02%	778	6.15%	1,414	4.55%	2,206	4.04%	3,278	563%	5.55%	
INDONESIA												
Harv'd Area (ha)	260	2.64%	289	2.60%	374	2.19%	464	2.00%	566	117%	2.24%	
Yield (kg/ha)	7.231	6.64%	9.350	2.68%	12.183	1.97%	14.803	1.66%	17.458	141%	2.55%	-58.6%
Prod'n (t)	1,882	9.45%	2,701	5.35%	4,551	4.20%	6,868	3.70%	9,873	425%	4.85%	
Population	164,630	1.84%	180,384	1.82%	216,100	1.31%	246,100	1.04%	273,000	66%	1.46%	
Consump.(t/cap/y)	0.011	5.55%	0.015	3.47%	0.021	2.86%	0.028	2.63%	0.036	216%	3.34%	

FRUIT	1985 x 1000	1985-89 % p.a.	1989 x 1000	1990-2000 % p.a.	2000 x 1000	2001-2010 % p.a.	2010 x 1000	2011-2020 % p.a.	2020 x 1000	1985-2020 net	1985-2020 % p.a.	1985-2020 %d land
ON-JAVA												
Harv'd Area (ha)												
Yield (kg/ha)												
Prod'n (t)												
OFF-JAVA												
Harv'd Area (ha)												
Yield (kg/ha)												
Prod'n (t)												
INDONESIA												
Harv'd Area (ha)	578	0.95%	600	2.50%	787	2.50%	1,008	2.50%	1,290	123%	2.32%	
Yield (kg/ha)	7.192	0.10%	7.220	2.00%	8.977	1.50%	10.418	1.00%	11.508	60%	1.35%	-37.5%
Prod'n (t)	4,155	1.05%	4,332	4.55%	7,067	4.04%	10,498	3.53%	14,845	257%	3.71%	
Population	164,630	1.84%	180,384	1.82%	216,100	1.31%	246,100	1.04%	273,000	66%	1.46%	
Consump.(t/cap/y)	0.025	-0.99%	0.024	3.14%	0.033	2.69%	0.043	2.46%	0.054	115%	2.22%	

NON-RICE FOOD	1985	1985-90	1990	1991-2000	2000	2001-2010	2010	2011-2020	2020	1985-2020	1985-2020	1985-2020
	x 1000	% p.a.	x 1000	% p.a.	x 1000	% p.a.	x 1000	% p.a.	x 1000	net	% p.a.	%d land
ON-JAVA												
Harv'd Area (ha)	3,509	3.56%	4,180	0.80%	4,527	0.52%	4,766	0.33%	4,925	40%	0.97%	
Yield (kg/ha)	4.379	0.63%	4.519	0.91%	4.948	0.99%	5.459	1.02%	6.042	38%	0.92%	-27.5%
Prod'n (t)	15,365	4.22%	18,891	1.72%	22,397	1.51%	26,016	1.35%	29,756	94%	1.91%	
OFF-JAVA												
Harv'd Area (ha)	2,146	5.19%	2,764	1.56%	3,228	1.12%	3,608	0.98%	3,979	85%	1.78%	
Yield (kg/ha)	3.944	-0.29%	3.886	0.16%	3.949	0.72%	4.243	1.00%	4.687	19%	0.49%	-15.9%
Prod'n (t)	8,463	4.88%	10,741	1.73%	12,748	1.85%	15,309	1.99%	18,652	120%	2.28%	
INDONESIA												
Harv'd Area (ha)	6,232	3.91%	7,550	1.24%	8,542	0.94%	9,382	0.83%	10,194	64%	1.42%	
Yield (kg/ha)	4.490	0.13%	4.519	0.90%	4.942	1.12%	5.524	1.17%	6.205	38%	0.93%	-27.6%
Prod'n (t)	27,983	4.04%	34,115	2.15%	42,212	2.07%	51,824	2.01%	63,252	126%	2.36%	
Population	164,630	1.84%	180,384	1.82%	216,100	1.31%	246,100	1.04%	273,000	66%	1.46%	
Consump (t/cap/y)	0.170	2.16%	0.189	0.32%	0.195	0.75%	0.211	0.96%	0.232	36%	0.89%	

Composition of Production.

	1985	1985-90	1990	1991-2000	2000	2001-2010	2010	2011-2020	2020	1985-2020	1985-2020
Area	%	% p.a.	%	% p.a.	%	% p.a.	%	% p.a.	%	net	% p a.
Staples	86.6%	0.34%	88.0%	-0.19%	86.4%	-0.61%	84.3%	-0.75%	81.8%	3%	-0.16%
Vegetables	4.2%	-1.73%	3.8%	1.34%	4.4%	3.12%	4.9%	2.92%	5.5%	33%	0.81%
Fruit	9.3%	-3.03%	7.9%	1.49%	9.2%	3.90%	10.7%	4.18%	12.7%	37%	0.89%
Output											
Staples	78.4%	-0.06%	78.2%	-0.76%	72.5%	-2.13%	66.5%	-2.16%	60.9%	-22%	-0.72%
Vegetables	6.7%	3.32%	7.9%	3.13%	10.8%	5.29%	13.3%	4.18%	15.6%	132%	2.43%
Fruit	14.8%	-3.08%	12.7%	2.80%	16.7%	4.68%	20.3%	3.75%	23.5%	58%	1.32%